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Corn Objective Yield: Operational vs. Non-Invasive Maturity Category Determinations

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CORN OBJECTIVE YIELD: OPERATIONAL vs. NON-INVASIVE MATURITY CATEGORY DETERMINATIONS. By Ronald J. Steele, Research and Applications Division, National Agricultural Statistics Service, U.S. Department of Agriculture, Washington, D.C. 20250, Staff Report No. SRB 87-04, August 1987.

ABSTRACT

Corn Objective Yield Survey sample plots are cross-classified on the basis of two alternative procedures for post-stratifying the sample into maturity categories. A null model of symmetry, using a multinomial sampling model, is adopted to test for systematic differences in the manner the two procedures post-stratify the sample. Significant differences between the operational and non-invasive procedures for post-stratifying the sample were detected for most states in August and September.

Jacknifed forecast errors tended to be larger when yield forecast equations were estimated with the sample post-stratified by the non-invasive procedure.

KEYWORDS: Symmetric tables, multinomial sample model, product-multinomial sample model, jacknife.

ACKNOWLEDGEMENTS

Special thanks to all the NASDA enumerators who gathered the data for this research project. Thanks also to Paul Williams for his numerous suggestions in implementing this project in a manner that would have minimal impact on the operational Corn Objective Yield Survey. And finally, my sincere appreciation to Bill Warde for introducing me to the wonderful book by Bishop, Fienberg and Holland.

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SUMMARY

Using the incorrect forecast equation and contaminating the data used to estimate the forecast equations are two types of errors which can arise due to the invasive nature of the operational procedure for post-stratifying the corn objective yield sample into maturity categories. A non-invasive procedure for post-stratifying sample plots into maturity categories was implemented in the Corn Objective Yield Survey on a parallel test basis in 1985.

There was a significant difference in the post-stratification of the sample between the non-invasive research procedure and the invasive operational procedure. Furthermore, forecast models estimated within maturity categories determined by the operational procedure tended to have smaller average forecast errors than when the maturity categories were determined by the research procedure. This study was not designed to allow definitive conclusions about why the observed differences exist. However, the two procedures do not result in the same post-stratification of the sample, and the forecast errors appear to be larger with the research procedure, it is recommended that the research effort be discontinued, and that the current operational procedure for post-stratifying the sample into maturity categories be retained.

CORN OBJECTIVE YIELD: OPERATIONAL vs. NON-INVASIVE MATURITY CATEGORY DETERMINATIONS

Ronald J. Steele

INTRODUCTION

The National Agricultural Statistics Service (NASS) of the U.S. Department of Agriculture (USDA) conducts monthly Corn Objective Yield (COY) surveys from August through November to forecast end-of-season yield of corn for grain for the ten major corn producing states. Gross yield is forecast using different equations for each maturity category. Samples are post-stratified into maturity categories based on observable plant and/or fruit characteristics. Once ears have formed, the husks are pulled back on the first five ears outside a pre-specified plot and row to observe the maturity stage. Due to the invasive nature of the operational procedure, different ears must be used each month. The plot and row numbers are rotated each month to obtain maturity category determinations from ears which have not previously been husked. This rotation, the variability of the maturity stage of ears within a field, and the fact that determinations are made on ears outside the sample plots creates the potential for post-stratifying sample units into an incorrect maturity category. The two primary errors which arise as a result of misclassification are: 1) using the incorrect forecast equation ; and 2) contaminating the data used to develop the forecast equations.

A non-invasive procedure for post-stratifying the sample into maturity categories was tested parallel with the operational procedure in 1985. The new procedure required the enumerators to examine the ears inside each sample plot, without damaging the ears, and subjectively evaluate the average maturity for the plot.

This study examines the relationship between the maturity categories samples are assigned to by the two procedures to determine if the two procedures result in approximately the same post-stratification of the sample. Forecast errors are compared between models developed within maturity categories as determined by the two procedures.

METHODOLOGY

A brief description of the COY sampling, data collection and forecasting methodologies is included here. More comprehensive discussions are contained in [4].

Table 1 shows the numbers of samples selected within each state in the COY program.

TABLE 1: Corn Objective Yield Sample Size for 1985 and 1986.

State	Sample Size Aug. 1 1/	Sept. 1 Until Harvest
Illinois	130	260
Indiana	105	210
Iowa	120	240
Michigan	55	110
Minnesota	105	210
Missouri	75	150
Nebraska	120	240
Ohio	95	190
South Dakota	70	140
Wisconsin	85	170
10 State Total	960	1,920

Sample units consist of two plots. Each plot is fifteen feet long and contains two rows. The plots are located within selected corn fields by counting pre-assigned, random numbers of rows and paces into the selected field. Fields are systematically selected with probabilities proportional to size from a list of fields identified during the June Enumerative Survey as being planted with corn for grain. Counts, measurements and observations of plant characteristics are made within these sample plots during the monthly survey periods.

The operational procedure for determining the maturity category changes as the growing season progresses. The enumerators husk the first five ears or silked ear shoots beyond Row 1 of Unit 2 for the August survey and beyond Row 1 of Unit 1 for the September survey. For the October and November surveys, the enumerators husk the first five ears with kernel formation beyond Row 2 of Units 1 and 2, respectively. If ears or silked ear shoots are

not yet present, the sample is assigned to maturity category 1. Otherwise, the enumerators assess and code the maturity stage of each of the five ears using the following coding scheme: 2 - pre-blister; 3 - blister; 4 - milk; 5 - dough; 6 - dent; and 7 - mature. The sample is post-stratified into maturity categories based on the sum of the coded maturity stages of the five ears.

The alternative non-invasive procedure being examined in this study required the enumerators to subjectively evaluate the average maturity stage of all ears in each plot, without damaging any of the ears. The enumerators then assigned one of the maturity codes listed above to the plot. The appendix contains copies of the survey instrument used to gather these data.

The maturity category of the sample affects which measurements are made, which forecast equations are used, when the enumerator harvests the sample plots, and which historic observations are grouped together to estimate the forecast equations for each maturity category.

When the corn reaches maturity, a count is made of the final number of ears in the sample plots, and the ears are harvested and weighed. A sample of ears is sent to a laboratory to determine an adjustment factor for converting field weight to grain weight at 15.5% moisture. This adjustment factor is applied to the weight of the ears harvested from the sample unit, and the result divided by the final number of ears to obtain the final average grain weight per ear. Final gross yield is calculated from the final number of ears, final average grain weight per ear, and the size of the sample plots. Post-harvest gleaning surveys are conducted to estimate the harvest loss. Estimated harvest loss is subtracted from final gross yield to obtain final net yield.

With data from the five previous years' COY surveys, simple linear regression models are used to estimate relationships between counts (or measurements) obtained during the growing season and counts made when the corn is mature. Forecasts of the final number of ears and average grain weight per ear are computed by applying these estimated regression relationships to counts and measurements made during the current growing season. Counts of stalks, stalks with ears, or number of ears are used as the predictor variable for final number of ears, depending on the stage of physiological development (maturity stage). Average kernel row length and average cob length over the husk are used to predict average grain weight per ear once the crop reaches a maturity stage sufficient to make these measurements. A historic average grain weight per ear is used prior to the development of kernels on ears. The yield forecast (bushels/acre) is computed by taking the product of the forecast number of ears, the forecast grain weight per ear and a multiplicative constant, divided by the area in the sample unit. Salient features of the

forecasting procedures, beyond those described above, are:

a) generally speaking, forecasts for number of ears and average grain weight per ear are each a weighted average of two forecasts, with weights based on average R^2 values of the estimated regression relationships across maturity categories. In some maturity categories, historic averages or observed data are used instead of forecasts from models;

b) regression relationships are estimated using data for the same state, district, month and maturity category from the previous years;

c) automated outlier/leverage-point detection and removal procedures are used in developing the forecast equations;

d) if there are insufficient data from previous years within some maturity category to estimate the regression relationships, a forecast equation from another maturity category, month or year is used. In selecting the forecast equation to be substituted, equations from within the same month are considered first, then equations from other months, and finally equations from other years.

e) if the estimated intercept parameter is negative, the model is forced through the origin (zero intercept). If the slope parameter is negative, a regression equation from another maturity category, month or year is substituted following the procedures discussed in (d) above.

ANALYSIS PROCEDURES

Tests for Systematic Misclassification

The non-invasive, research determinations of maturity category were made for each of the two plots in the sample unit. The invasive, operational determination was made for the entire sample unit based solely on observations made outside one of the plots. For the purposes of this analysis the original sample design was ignored, plots were treated as the sample units, and both plots were assigned to the same maturity category for the operational procedure. Within a month and state, the number of plots classified into each maturity category by the two procedures can be crosstabulated as follows:

			OPERATIONAL	MATURITY		CATEGORY	
Frequency			1	2	...	7	Total
R	M	1	x_{11}	x_{12}	...	x_{17}	x_{1+}
E	A	2	x_{21}	x_{22}	...	x_{27}	x_{2+}
S	T.	.	.	.		.	.
E		.	.	.		.	.
A	C	.	.	.		.	.
R	A	7	x_{71}	x_{72}	...	x_{77}	x_{7+}
C	T.						
H	Total		x_{+1}	x_{+2}	...	x_{+7}	x_{++}

where x_{ij} is the count of the number of plots classified into maturity category i by the research procedure, and maturity category j by the operational procedure. The maturity category is assumed known for the plots included in the counts along the diagonal - the plots where both procedures resulted in the same maturity category determination. Otherwise, we presume that either procedure may have classified the plot into an incorrect maturity category. The overall sample size in a month and state, x_{++}, is considered fixed, and each of the x_{i+} and x_{+j} are random. A multinomial sample model is appropriate under these assumptions. We adopt a null model of symmetry:

$$m_{ij}=m_{ji} \quad \text{where} \quad m_{ij}=E(x_{ij}) .$$

This null model in essence states that there are no systematic patterns of misclassification by the two procedures. The maximum likelihood estimates of the m_{ij}'s are: $\hat{m}_{ij}=(x_{ij}+x_{ji})/2$ [Bishop, Fienberg & Holland, pp.282-283]. When i=j, this reduces to $\hat{m}_{ii}=x_{ii}$. The asymptotically chi-squared goodness-of-fit statistic used to test the hypothesis of symmetry is:

$$X^2=\sum_{i>j} (x_{ij}-x_{ji})^2/(x_{ij}+x_{ji}) \quad .$$

Since not all cells will have non-zero values within a given month and state, we consider the i,j^{th} cell to be structurally zero if and only if $\hat{m}_{ij}=0$. This is equivalent to the condition $x_{ij}=x_{ji}=0$. The appropriate degrees of freedom is the number of cells with $\hat{m}_{ij}\neq0$, $i>j$.

The ten states within a given month have independently selected samples, with sample sizes pre-established for each state. Thus, over the ten states within a given month, we have a product-multinomial sample model, and the goodness-of-fit statistic for testing the hypothesis of symmetry over all ten states simultaneously is:

$$X^2 = \sum_k X_k^2$$ where X_k^2 is the goodness-of-fit statistic for the k^{th} state on d_k degrees of freedom. This statistic is asymptotically chi-squared on $\sum_k d_k$ d.f.

The goodness-of-fit statistics for the model of symmetry are presented, by month, in Table 2. In those tables, the effective sample sizes are tabulated, as well as the total sample size. The effective sample size is the number of plots where the maturity categories the plot was classified into by the two procedures differed. Also included in the table is the Goodman-Kruskal coefficient of association for ordered categories [Kendall & Stuart, pp.585-586].

Table 2: Chi-Squared Test of Hypothesis of Symmetry

	X^2	df	$Pr>X^2$	N	Effective N	Goodman-Kruskal
August						
10 States	122.80	30	0.000	1582	182	
Illinois	15.11	3	0.002	224	24	0.78
Indiana	19.62	3	<0.001	182	33	0.62
Iowa	21.64	4	<0.001	200	33	0.56
Michigan	6.00	2	0.050	86	6	0.86
Minnesota	12.00	2	0.003	176	12	0.85
Missouri	8.43	6	0.208	134	25	0.74
Nebraska D1	10.00	3	0.019	62	10	0.71
Nebraska D2	9.00	3	0.029	128	9	0.80
Ohio	4.00	2	0.135	152	13	0.83
So. Dakota	7.00	1	0.008	104	7	0.86
Wisconsin	10.00	1	0.002	134	10	0.85
September						
10 States	129.83	48	0.000	3156	354	
Illinois	11.39	5	0.044	456	55	0.80
Indiana	16.32	4	0.003	336	41	0.82
Iowa	9.27	4	0.055	418	36	0.86
Michigan	11.25	4	0.024	182	29	0.68
Minnesota	14.59	5	0.012	338	30	0.82
Missouri	8.52	3	0.036	258	33	0.82
Nebraska D1	8.00	4	0.092	136	11	0.86
Nebraska D2	10.11	4	0.039	252	19	0.86
Ohio	9.20	6	0.163	318	50	0.78
So. Dakota	19.00	5	0.002	202	25	0.80
Wisconsin	12.18	4	0.016	260	25	0.80

(Continued on next page)

Table 2 (con't): Chi-Squared Test of Hypothesis of Symmetry

	X^2	df	$Pr>X^2$	N	Effective N	Goodman-Kruskal
October						
10 States	51.64	32	0.015	3114	210	
Illinois	6.77	2	0.034	450	16	0.96
Indiana	2.00	2	0.368	330	18	0.93
Iowa	4.38	2	0.112	416	19	0.93
Michigan	1.17	4	0.884	176	29	0.69
Minnesota	3.20	5	0.669	336	26	0.82
Missouri	3.74	2	0.154	258	17	0.93
Nebraska D1	1.14	2	0.565	136	8	0.90
Nebraska D2	3.80	3	0.284	252	11	0.91
Ohio	9.57	4	0.048	306	25	0.88
So. Dakota	4.00	3	0.262	194	8	0.87
Wisconsin	11.88	3	0.008	260	33	0.69
November						
10 States	41.67	21	0.005	2984	145	
Illinois	6.23	1	0.013	446	13	0.97
Indiana	0.40	1	0.527	310	10	0.97
Iowa	4.46	1	0.035	406	11	0.97
Michigan	0.90	2	0.638	164	18	0.88
Minnesota	5.33	4	0.255	314	17	0.94
Missouri	2.78	1	0.096	254	9	0.97
Nebraska D1	2.00	1	0.157	136	2	0.98
Nebraska D2	2.00	1	0.157	240	8	0.97
Ohio	11.23	3	0.010	296	18	0.94
So. Dakota	1.29	3	0.732	182	17	0.90
Wisconsin	5.06	3	0.168	236	22	0.90

In the first two months, there are significant departures from the null model for almost all states. In the last two months, the hypothesis of symmetry seems reasonable for most states.

For state and month combinations where we reject the hypothesis of symmetry, a McNemar-like statistic is computed to determine if either procedure has a tendency to classify the plots into higher maturity categories. [Bishop, Fienberg & Holland, p.285]. The McNemar-like test statistic:

$$X^2 = (b-c)^2/(b+c) \quad \text{where } b = \sum_{i>j} x_{ij} \quad \text{and } c = \sum_{i<j} x_{ij}$$

is asymptotically chi-squared on 1 d.f. This statistic is

presented in Table 3. Also presented is the number of times the research procedure assigned plots into a higher maturity category than the operational procedure (Research MC Higher), and vice versa (Operational MC Higher).

Table 3: McNemar-like Test for One Procedure Classifying Plots Into Higher Maturity Categories

	X^2	$Pr>X^2$	Research MC Higher	Operational MC Higher
August				
Illinois	8.17	0.004	5	19
Indiana	10.94	0.001	26	7
Iowa	13.36	0.000	27	6
Michigan	2.67	0.102	1	5
Minnesota	3.00	0.083	3	9
Nebraska D1	0.40	0.527	6	4
Nebraska D2	0.11	0.739	4	5
So. Dakota	7.00	0.008	0	7
Wisconsin	10.00	0.002	0	10
September				
Illinois	5.26	0.022	36	19
Indiana	0.02	0.876	20	21
Michigan	5.83	0.016	21	8
Minnesota	2.13	0.144	19	11
Missouri	0.03	0.862	17	16
Nebraska D2	0.05	0.818	10	9
So. Dakota	0.36	0.548	11	14
Wisconsin	0.36	0.548	14	11
October				
Illinois	6.25	0.012	3	13
Ohio	4.84	0.027	7	18
Wisconsin	0.03	0.862	16	17
November				
Illinois	6.23	0.013	2	11
Iowa	4.46	0.035	2	9
Ohio	8.00	0.005	3	15

Forecast Errors

To the extent possible, operational procedures were used to estimate the forecast equations, generate the forecasts, and estimate the forecast errors. Forecast equations were estimated within maturity categories, as determined by the two procedures. Since this research project was not carried out for several years, we could not use data from previous years to estimate the regression relationships. Jacknife procedures [Efron, pp.1-3] were used to obtain yield forecasts independent from the forecast equations while using only one years' data. Essentially, with n observations for a given month and maturity category combination, one observation is set aside, the other n-1 observations are used to estimate the forecast equations, and the final yield is forecast for the one observation which was set aside. This procedure is repeated n times within that month and maturity category combination. Average forecast errors and average absolute forecast errors are obtained by subtracting the forecast from the actual final gross yield, and averaging across all samples. These forecast errors are shown in Table 4.

In a majority of instances, the operational procedure has the smaller average and average absolute forecast error.

CONCLUSIONS

The two procedures do not appear to result in the same post-stratification of the sample. There are statistically significant differences between the maturity categories plots are assigned to by the two procedures for 8 out of 10 states in August and September, and for 3 out of 10 states in October and November. This study was not designed to allow definitive conclusions about why the observed differences exist, or which procedure is better - only that the two are different.

In a majority of instances, the operational procedure had a smaller average and average absolute forecast error than did the research procedure.

RECOMMENDATIONS

Since the two procedures do not result in the same post-stratification of the sample, and the forecast errors appear to be larger with the research procedure, I recommend we discontinue this research effort, remove Item 6.b. from the Form B's of the Corn Objective Yield Survey, and retain the current operational procedure for post-stratifying the sample into maturity categories.

Table 4: Average and Average Absolute Forecast Errors in Bushels/Acre.

State	Month	N	Average Error Research	Average Error Operational	Ave. Absol. Error Research	Ave. Absol. Error Operational
Ill.	Aug	110	0.948	0.879	39.180	35.718
	Sep	218	1.078	0.847	33.568	29.623
	Oct	222	0.380	0.043	16.833	15.087
Ind.	Aug	80	2.036	3.215	35.070	29.819
	Sep	144	1.953	2.117	29.857	25.633
	Oct	151	0.145	0.387	17.775	15.776
Iowa	Aug	94	1.446	4.699	40.195	35.203
	Sep	193	1.216	1.507	27.476	23.585
	Oct	198	0.741	0.453	17.084	14.242
Mich	Aug	40	2.756	3.320	35.475	32.172
	Sep	78	0.006	0.511	25.753	19.778
	Oct	77	0.726	0.618	17.324	16.612
Minn	Aug	77	-4.655	-3.482	36.687	34.294
	Sep	154	-0.438	-0.387	29.361	26.495
	Oct	155	0.547	-0.110	28.904	26.840
MO.	Aug	59	4.848	3.133	31.398	28.081
	Sep	124	0.831	0.729	25.720	22.022
	Oct	125	-0.111	-0.218	11.254	8.778
Neb(1)	Aug	28	-5.802	-8.013	26.739	26.631
	Sep	61	1.469	2.764	27.204	20.821
	Oct	65	-0.686	-0.804	19.116	17.592
Neb(2)	Aug	60	4.483	4.659	35.084	31.898
	Sep	116	1.910	1.452	29.042	23.915
	Oct	116	2.221	2.190	26.998	26.022
Ohio	Aug	66	-0.620	0.107	43.117	37.434
	Sep	145	0.605	0.660	33.195	27.678
	Oct	141	1.222	1.197	23.742	21.732
SDak	Aug	43	-2.534	-2.033	26.296	26.844
	Sep	86	1.826	1.450	26.968	24.417
	Oct	88	0.565	0.534	21.924	20.929
Wisc	Aug	57	-2.073	-0.864	39.562	33.734
	Sep	106	-0.334	0.138	33.898	27.048
	Oct	103	1.066	0.248	25.171	24.698

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APPENDIX: Corn Objective Yield Form B

UNITED STATES DEPARTMENT OF AGRICULTURE
STATISTICAL REPORTING SERVICE

Form Approved
O.M.B. Number 0535-0088
Expiration Date 7/31/89
C.E. 12-00328-1

FORM B—1: CORN YIELD COUNTS — August 1, 1986

YEAR, CROP, FORM, MONTH (1—4)
6431

Has operator applied pesticides with organophosphorous content since last field visit? YES ☐ NO ☐

If YES, enter latest application date ________ *and name of pesticide* ________.

UNIT LOCATION

	UNIT 1	UNIT 2
Number of rows along edge of field		
Number of paces into field		

Date (________) 370

Starting Time *(Military Time)* 371

UNIT LOCATION CODE

1. a. First visit to lay out unit 1
   b. Unit relocated this month 2
   c. Sample unit laid out previously 3

Enter Code

UNIT 1	UNIT 2
302	307

Skip To Item 3 if code 3

ROW SPACE MEASUREMENTS

		UNIT 1	UNIT 2
2. a. Measure distance from stalks in Row 1 to stalks in Row 2	Feet & Tenths	303 .	304 .
b. Measure distance from stalks in Row 1 to stalks in Row 5	Feet & Tenths	305 .	306 .

COUNTS WITHIN 15-FOOT UNITS

	ROW 1	ROW 2	ROW 1	ROW 2
3. Number of stalks	331	332	333	334
4. Number of stalks with ears or silked ear shoots *(Item 4 cannot exceed Item 3 for any row)*	341	342	343	344
5. Number of ears and silked ear shoots *(Item 5 must equal or exceed Item 4 for any row)*	351	352	353	354
6. a. Number of ears with evidence of kernel formation *(Item 6 cannot exceed Item 5 for any row)*	361	362	363	364
b. Stage of maturity. If ears or silked ear shoots are not yet present enter a code "1". *(Do not disturb ears inside the unit)*	385		386	

OBSERVATIONS BEYOND UNIT 2, ROW 1 ONLY:

Husk the first 5 ears or silked ear shoots beyond Row 1 and examine for maturity. If ears or silked ear shoots are not yet present CHECK ( ) and skip Items 7—13.

Maturity Stage	Code	Maturity Stage	Code
Pre-Blister	2	Dough	5
Blister	3	Dent	6
Milk	4	Mature	7

	Ear Number 1	2	3	4	5	Total of 5 Ears
7. Maturity stage of first 5 ears or silked ear shoots						301

If total in Item 7 is
- 12 or less, skip Items 8 through 13.
- 13 or more, continue. (If any ears in Item 7 are Code 2, replace each Code 2 ear with the next Code 3 ear or higher and enter in Item 8.)

UNITED STATES DEPARTMENT OF AGRICULTURE
STATISTICAL REPORTING SERVICE

Form Approved
O.M.B. Number 0535-0088
Expiration Date 7/31/89
C.E. 12-00328-2

FORM B—2: CORN YIELD COUNTS — September 1, 1986

YEAR, CROP, FORM, MONTH (1—4)
6432

Has operator applied pesticides with organophosphorous content since last field visit? YES ☐ NO ☐

If YES, enter latest application date __________ *and name of pesticide* __________.

UNIT LOCATION

	UNIT 1	UNIT 2
Number of rows along edge of field		
Number of paces into field		

Date (__________) 370

Starting Time *(Military Time)* 371

UNIT LOCATION CODE

1. a. First visit to lay out unit 1
   b. Unit relocated this month 2
   c. Sample unit laid out previously 3

Enter Code

UNIT 1	UNIT 2
302	307

Skip To Item 3 if code 3

ROW SPACE MEASUREMENTS

	UNIT 1	UNIT 2
a. Measure distance from stalks in Row 1 to stalks in Row 2 .... Feet & Tenths	303 .	304 .
b. Measure distance from stalks in Row 1 to stalks in Row 5 .... Feet & Tenths	305 .	306 .

COUNTS WITHIN 15-FOOT UNITS

	ROW 1	ROW 2	ROW 1	ROW 2
3. Number of stalks	331	332	333	334
4. Number of stalks with ears or silked ear shoots *(Item 4 cannot exceed Item 3 for any row)*	341	342	343	344
5. Number of ears and silked ear shoots *(Item 5 must equal or exceed Item 4 for any row)*	351	352	353	354
6. a. Number of ears with evidence of kernel formation *(Item 6 cannot exceed Item 5 for any row)*	361	362	363	364
b. Stage of maturity. If ears or silked ear shoots are not yet present enter a code "1". *(Do not disturb ears inside the unit)*	385		386	

OBSERVATIONS BEYOND UNIT 1, ROW 1 ONLY:

Husk the first 5 ears or silked ear shoots beyond Row 1 and examine for maturity. If ears or silked ear shoots are not yet present CHECK ( ) and skip Items 7—13.

Maturity Stage	Code	Maturity Stage	Code
Pre-Blister	2	Dough	5
Blister	3	Dent	6
Milk	4	Mature	7

	Ear Number				Total of 5 Ears
	1	2	3	4	5	
7. Maturity stage of first 5 ears or silked ear shoots						301

If total in Item 7 is
- 12 or less, skip Items 8 through 13.
- 13 or more, continue. (If any ears in Item 7 are Code 2, replace each Code 2 ear with the next Code 3 ear or higher and enter in Item 8.)

UNITED STATES DEPARTMENT OF AGRICULTURE
STATISTICAL REPORTING SERVICE

Form Approved
O.M.B. Number 0535-0088
Expiration Date 7/31/89
C.E. 12-0032B-3

FORM B—3: CORN YIELD COUNTS — October 1, 1986

YEAR, CROP, FORM, MONTH (1—4)
6433

Has operator applied pesticides with organophosphorous content since last field visit? YES ☐ NO ☐

If YES, enter latest application date ____________ *and name of pesticide* ____________.

UNIT LOCATION

	UNIT 1	UNIT 2
Number of rows along edge of field		
Number of paces into field		

Date (____________) 370

Starting Time *(Military Time)* 371

UNIT LOCATION CODE

1. a. First visit to lay out unit 1
   b. Unit relocated this month 2
   c. Sample unit laid out previously 3

Enter Code

UNIT 1	UNIT 2
302	307

Skip To Item 3 If Code 3

ROW SPACE MEASUREMENTS

	UNIT 1	UNIT 2
2. a. Measure distance from stalks in Row 1 to stalks in Row 2 .... Feet & Tenths	303 .	304 .
b. Measure distance from stalks in Row 1 to stalks in Row 5 .... Feet & Tenths	305 .	306 .

COUNTS WITHIN 15-FOOT UNITS

	ROW 1	ROW 2	ROW 1	ROW 2
3. Number of stalks	331	332	333	334
4. Number of stalks with ears or silked ear shoots *(Item 4 cannot exceed Item 3 for any row)*	341	342	343	344
5. Number of ears and silked ear shoots *(Item 5 must equal or exceed Item 4 for any row)*	351	352	353	354
6. a. Number of ears with evidence of kernel formation *(Item 6 cannot exceed Item 5 for any row)*	361	362	363	364
b. Stage of maturity. *(Do not disturb ears inside the unit)*	385		386	

OBSERVATIONS BEYOND UNIT 1, ROW 2 ONLY:

Husk the first 5 ears with evidence of kernel formation (Codes 3—7) beyond Row 2 and examine for maturity.

Maturity Stage	Code	Maturity Stage	Code
Pre-Blister	2	Dough	5
Blister	3	Dent	6
Milk	4	Mature	7

	Ear Number				
	1	2	3	4	5
8. Maturity stage of first 5 ears Code 3 or higher	320	321	322	323	324

Does Item 8 have 3 or more Code 7 ears?

☐ **YES**, *Complete Items 12 through 14 only.*

☐ **NO**, *Continue.*

UNITED STATES DEPARTMENT OF AGRICULTURE
STATISTICAL REPORTING SERVICE

Form Approved
O.M.B. Number 0535-0088
Expiration Date 7/31/89
C.E. 12-00328-4

FORM B—4: CORN YIELD COUNTS — November 1, 1986

YEAR, CROP, FORM, MONTH (1—4)
6434

Has operator applied pesticides with organophosphorous content since last field visit? YES ☐ NO ☐

If YES, enter latest application date ______________ *and name of pesticide* ______________.

UNIT LOCATION	UNIT 1	UNIT 2
Number of rows along edge of field		
Number of paces into field		

Date (______________) 370

Starting Time *(Military Time)* 371

UNIT LOCATION CODE

1. a. First visit to lay out unit 1
   b. Unit relocated this month 2
   c. Sample unit laid out previously 3

Enter Code

UNIT 1	UNIT 2
302	307

Skip To Item 3 If Code 3

OW SPACE MEASUREMENTS

	UNIT 1	UNIT 2
2. a. Measure distance from stalks in Row 1 to stalks in Row 2 .... Feet & Tenths	303 .	304 .
b. Measure distance from stalks in Row 1 to stalks in Row 5 .... Feet & Tenths	305 .	306 .

COUNTS WITHIN 15-FOOT UNITS

	ROW 1	ROW 2	ROW 1	ROW 2
3. Number of stalks	331	332	333	334
4. Number of stalks with ears or silked ear shoots *(Item 4 cannot exceed Item 3 for any row)*	341	342	343	344
5. Number of ears and silked ear shoots *(Item 5 must equal or exceed Item 4 for any row)*	351	352	353	354
6. a. Number of ears with evidence of kernel formation *(Item 6 cannot exceed Item 5 for any row)*	361	362	363	364
b. Stage of maturity. *(Do not disturb ears inside the unit)*	385		386	

OBSERVATIONS BEYOND UNIT 2, ROW 2 ONLY:

Husk the first 5 ears with evidence of kernel formation (Codes 3—7) beyond Row 2 and examine for maturity.

Maturity Stage	Code	Maturity Stage	Code
Pre-Blister	2	Dough	5
Blister	3	Dent	6
Milk	4	Mature	7

	Ear Number 1	2	3	4	5
8. Maturity stage of first 5 ears Code 3 or higher	320	321	322	323	324

Does Item 8 have 3 or more Code 7 ears?
- ☐ **YES,** *Complete Items 12 through 14 only.*
- ☐ **NO,** *Continue.*

UNITED STATES DEPARTMENT OF AGRICULTURE
STATISTICAL REPORTING SERVICE

Form Approved
O.M.B. Number 0535-0088
Expiration Date 7/31/89
C.E. 12-0032B-5

FORM B—5: CORN YIELD COUNTS — After November 1, 1986

YEAR, CROP, FORM, MONTH (1—4)
6435

Has operator applied pesticides with organophosphorous content since last field visit? YES ☐ NO ☐

If YES, enter latest application date ________________ *and name of pesticide* ________________.

UNIT LOCATION

	UNIT 1	UNIT 2
Number of rows along edge of field		
Number of paces into field		

Date (________________)	370
Starting Time *(Military Time)*	371

UNIT LOCATION CODE

1. a. First visit to lay out unit 1
   b. Unit relocated this month 2
   c. Same unit laid out previously 3

Enter Code

UNIT 1	UNIT 2
305	307

Skip to Item 3 if Code 3.

ROW SPACE MEASUREMENTS

	UNIT 1	UNIT 2
2. a. Measure distance from stalks in Row 1 to stalks in Row 2.........................Feet & Tenths	303 .	304 .
b. Measure distance from stalks in Row 1 to stalks in Row 5 ....Feet & Tenths	305 .	306 .

COUNTS WITHIN 15-FOOT UNITS

	Row 1	Row 2	Row 1	Row 2
3. Number of stalks	331	332	333	334
6. a. Number of ears with evidence of kernel formation	361	362	363	364
b. Stage of maturity.................... *(Do not disturb ears inside the Unit)*	385		386	

(NOTE: Before proceeding to unit 2, complete Items 12, 13 and 14.)